

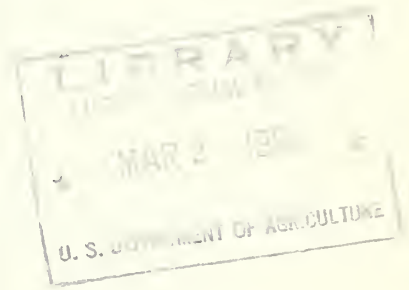
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DURABILITY of CELLOPHANE for PACKAGING RICE for CONSUMER TRADE



PREFACE

This report will supplement the research findings published by the Department of Agriculture in June 1952 entitled "Trends in Packaging Materials and Equipment for Dry Edible Beans and Related Commodities." Increased consumer purchases of trade brand packages emphasized the need for more research on types and kinds of packages best suited for the retailing of rice.

According to the trade 1-, 2-, and 3-pound packages are the sizes most in demand. At the recommendation of the Rice Research and Marketing Advisory Committee, research was undertaken to develop and improve rice packages.

It is recognized that the attractiveness of rice packages has played an important part in maintaining sales at a higher level. The use of transparent film packages has increased continually, gradually replacing many of the old costly methods of weighing and packaging quantities of rice individually in the Southern States.

This work was done in cooperation with the following:

Louisiana State Rice Mills, Crowley, La.
Louisiana State Rice Experiment Station, Crowley, La.
Sylvania Division, American Viscose Corp., Philadelphia, Pa.
Agricultural Engineering Department, Michigan State University, East Lansing, Mich.
St. Regis Paper Co., 230 Park Avenue, New York, N. Y.
Shellmar-Betner Division, Continental Can Co.,
Mt. Vernon, Ohio

The author expresses his appreciation to T. H. Derby, Market Development Department, Sylvania Division, American Viscose Corporation, Philadelphia, Pa., who supplied a large part of the film and offered valuable guidance to the research; and to John S. Perry, Michigan State University; Earl A. Sonnier, L. George Coonrod, and R. K. Walker, of the Louisiana Rice Experiment Station; and Curtis Hoffpauir, Louisiana State Rice Mills, for their important part in carrying out this research.

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CONCLUSIONS AND RECOMMENDATIONS

The geographical location has a marked effect on cellophane package durability. Package breakage at East Lansing, Mich. (cold and dry), was over 3 times as severe as at Marcus Hook, Pa. (temperate), and over 6 times as pronounced as at Crowley, La. (warm and humid).

Packaged rice should be marketed soon after packaging. There was little breakage during the first 3 months in any film construction.

These tests emphasized the importance of proper bag fabrication and sealing to avoid failures of seams at top and bottom. The heavier the package, the more critical are the sealing conditions.

The MS-3 type film, sealed either by heat or by pressure-sensitive tape, is moistureproof, and assures little variation in weight during marketing.

Regarding cellophane packages of specific weights, the following conclusions were reached:

1-Pound

- a. The duplex 300 MS-3 gave the best results.
- b. If single-wall bags are desired, the 450 weight is recommended.
- c. Single-wall 300-weight films are not recommended for wide geographical distribution or for long storage periods.

2-Pound

- a. For moistureproof packages, the duplex 300 MS-3 was most satisfactory.
- b. For nonmoistureproof packages, the duplex 300-P-1 gave excellent durability, but had greatest weight fluctuation.
- c. The single-wall heavier-gage 450 MS-3 was not so satisfactory as either of the above.

3-Pound

- a. Of the packages tested, the double-wall construction using 450 MS-3 inner wall, 300 MS-3 outer wall, gave the best results.
- b. Little difference was noted in durability between the duplex 300 MS-3 and duplex 450 MS-3. Whereas the 450-weight film had less breakage, it failed more often in sealing.

DURABILITY OF CELLOPHANE FOR PACKAGING RICE
FOR CONSUMER TRADE

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BACKGROUND OF STUDY

The research work covered by this report deals principally with studies of cellophane durability under various conditions of packaging and storing rice. Only packages holding 1, 2, and 3 pounds of rice were tested. A project to determine the kinds and weights of heavier transparent films for use on 5-pound containers is planned.

Practically all kinds of transparent cellophane have been used at some time or other for packaging rice. Unsuitable kinds often broke, resulting in loss of the commodity and expense to the packagers in replacing broken containers.

The quantity of rice packaged is becoming more significant each year. In 1947, the Bureau of the Census reported that 359,400,000 pounds of rice was packaged in containers holding 1, 2, and 3 pounds. The present census is expected to show a decided increase over this figure.

It is essential that exactly the correct weight and kind of film be used to obtain the durability necessary. The film may determine whether the rice in the bag becomes musty and moldy, and whether it loses or gains in weight. The film must be adaptable to the kind of bags made and the sealing equipment used.

The kind and weight of cellophane to use depends on a number of factors. Because of the chemical nature of cellophane, a variety and weight of film may be entirely satisfactory in one part of the country, or for rice of a certain moisture content, but unsatisfactory under other conditions. Also, some films that are entirely satisfactory for summer or in areas with high humidity may be almost useless in areas having low temperatures and low humidity. Another important point is the length of time the package is to be kept on the shelf before being sold. This all sums up to one thing: the need for selecting durable types of cellophane bag that are suitable for the conditions under which they are to be used.

Although most of the rice is packaged in the South and is used in that area, a sizable quantity is packaged and shipped to the Northern States. A number of shippers using films that were entirely satisfactory in the South found that the cold, dry atmosphere of the North, as well as the arid condition of parts of the Southwest, caused the cellophane to crack and weaken, often resulting in considerable breakage. To determine the effect of climate on rice packages, testing locations

were chosen to typify (1) temperate, (2) humid, and (3) cold and dry climatic conditions. In order, these were: Marcus Hook, Pa.; Crowley, La.; and East Lansing, Mich.

The solution of the problems outlined required the cooperation of a cellophane manufacturer, converter, and packager. Also, controlled laboratory storage facilities in the 3 areas had to be maintained for the test period.

Table 1 shows the approximate measurements of cellophane in general use for packaging rice, beans, peas, and related commodities.

Table 1.--Specifications for thickness and yield per pound of cellophane

Weight of film	Approximate measurements		
	Thickness	Yield per	Roll length
		pound	1/
	Inches	Square inches	Linear feet
300 plain.....	0.0009	21,500	5,375
450 plain.....	.0013	15,000	3,750
600 plain.....	.0016	12,400	3,100
300 moistureproof.....	.0010	19,500	4,875
450 moistureproof.....	.0014	14,000	3,500
600 moistureproof.....	.0017	11,600	2,900

1/ Length of roll based on standard roll that has a 9½-inch outside diameter and yields approximately 3 pounds per inch of width.

Characteristics of the various types of film used in this study are designated by codes, as follows:

M=Moistureproof
P=Plain, nonmoistureproof
S=Heat-sealing
T=Transparent, uncolored

The film designated P-1, used in this study, is approximately the equivalent of a film made by a different manufacturer and designated PT. Also, MS-3 is comparable with MST-53 and MST-54.

The films of weights 300, 450, and 600 (table 1) are approximately the same for all manufacturers. However, there may be slight differences between MS-3, MST-53, and MST-54. Therefore, the buyer of cellophane is advised to check with the manufacturer or converter to determine which films are comparable with the kinds described here.

PROCEDURE AND MATERIALS USED

The rice was packaged by the Louisiana State Rice Mills, Crowley, La. Arrangements were made with the Crowley Experiment Station to exchange with the Louisiana State Rice Mills sufficient rough rice for an equivalent amount of milled rice. The rice used in these tests was milled rice which graded U. S. No. 2 Blue Bonnet. It contained 7 percent of broken kernels and 0.7 percent of Red Rice and damaged kernels. Its moisture content was 10.32 percent.

Five hundred thirty-six bags of the various kinds of cellophane of the 1-, 2-, and 3-pound sizes were filled with standard low-moisture rice. In addition, a few 1-pound 450 MS-3 bags were packaged with rice containing 12.15 percent of moisture. Rough rice containing 16 percent of moisture had been milled to get a product of high moisture content, but processing not only dried it down to 12 percent but resulted in 68 percent of broken kernels.

The cellophane was supplied by the American Viscose Corporation of Philadelphia. The kind supplied, and the sizes of bags into which it was made, are shown in table 2.

Table 2.--Kind and weight of cellophane, and sizes of packages tested

Package code	Size of Package	Cellophane		
		Structure	Weight	Variety
	<u>Pounds</u>			
1 - L	1	Single	450	MS-3
2 - L	1	Duplex	300	MS-3
3 - L	2	Single	450	MS-3
4 - L	2	Duplex	300	MS-3
5 - L	2	Do.	300	P-1
6 - L	3	Do.	300	MS-3
7 - L	3	Do.	450	MS-3
8 - L	3	Do.	450 inner) 300 outer)	MS-3

Standard packaging equipment was used (figs. 1 and 2). The bags were made in one machine, and were then fed manually into the other machine to be automatically filled and heat-sealed.

Sixty-seven sets, or replicates, of each of the 8 kinds of bags were filled with rice. The packages were then moved to the Louisiana Rice Experiment Station, where they were sorted into 21 equal bales of 3 sets each and sealed with pressure-sensitive tape. Seven of the bales were expressed to Michigan State University, 7 to Marcus Hook laboratory, and 7 were retained at the Louisiana Rice Experiment Station. Another bale of packages was exposed to the air at the

Louisiana Station, the packages being weighed each month to determine loss or gain of weight. One set of packages (one-third bale) was sent to Washington, D. C., exposed to atmospheric conditions there, and the weight checked each month. At Michigan State University, a replicate was removed from one of the bales and checked for changes in weight; the other two sets in this bale were used for drop testing.

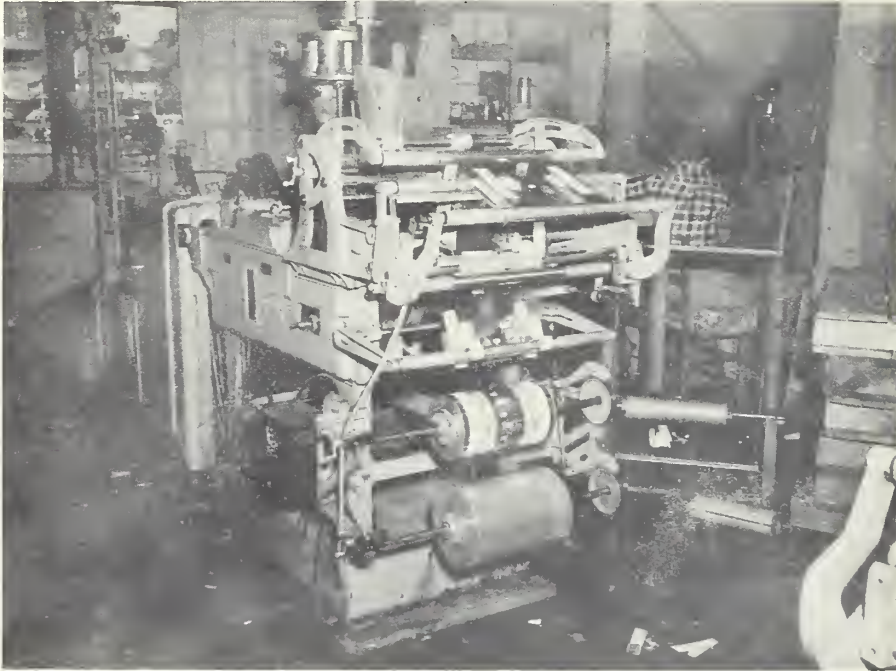


Figure 1.-- Automatic bag-making equipment used. Note the rolls of cellophane which the machine automatically cuts off, folds, and heat-seals, forming a bag ready to be filled and sealed by the equipment shown in figure 2.

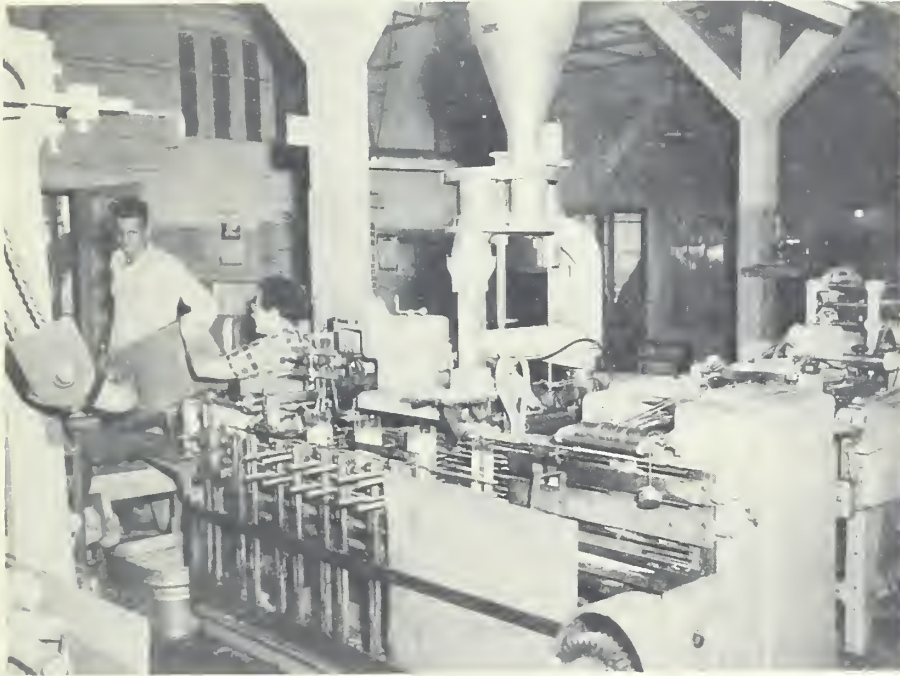


Figure 2.--Automatic packaging equipment used for packaging rice. Note the automatic volumetric feed at top center.

DROP TESTS

In the drop tests, the packaged rice was given much more severe treatment than that to which commercial packages are normally subjected. The tests were purposely made severe enough to insure a sizable number of breakages, so that the effect of weight and type of film could be analyzed.

The method of checking durability of packages was as follows: Periodically the bales of packaged rice were opened, and the three sets of each size of package and kind of film were drop-tested (fig. 3) by being dropped 12 inches.

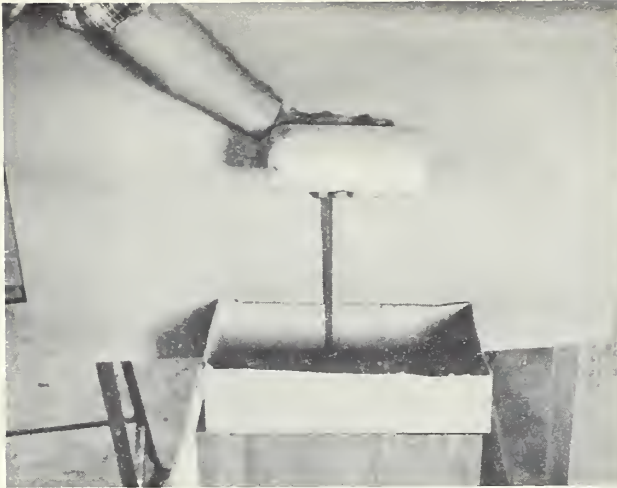


Figure 3.--Package is leveled at top of 1-foot rule and then dropped into the box. (Michigan State University)

Each package was dropped six ways, as follows:

1. Horizontal with seam down.
2. Horizontal with seam up.
3. Horizontal with right side up.
4. Horizontal with left side up.
5. Vertical upright.
6. Vertical inverted.

Tests at Marcus Hook Laboratory

At the Marcus Hook Laboratory of American Viscose Corporation, the rice packages were taken from the bales and weighed individually. The bales were then resealed and were stored under controlled atmospheric conditions of 60 percent relative humidity and 76° F. temperature. Drop tests to measure durability of the packages were made at the end of each 6-week period; the results are given in tables 3 and 4.

Table 3.--Results of drop tests measuring durability of the packages stored under controlled conditions at Marcus Hook, Pa.

Bale number:	Weeks stored:	Code:	Weight of package:	Film Kind:	Weight:	Drop at which failure occurred:	Location of break, length if at other than seam:
	Number		Pounds			Number	
1	6	-	-	-	-	-	(No break)
2	12	-	-	-	-	-	(No break)
3	18	3L	2	MS-3	450	6th	Side seam
4	24	3L	2	MS-3	450	6th	$\frac{1}{4}$ " tear
		7L	3	MS-3	D.W. 450	6th	Side seam
5	30	1H	1	MS-3	450	5th	Bottom seal
		2L	1	MS-3	D.W. 300	4th	Do.
		6L	3	MS-3	D.W. 300	3d	Top seal
		7L	3	MS-3	D.W. 400	2d	Do.
6	36	1L	1	MS-3	450	2d	$\frac{1}{8}$ " tear
		1L	1	MS-3	450	5th	$\frac{1}{2}$ " tear
		3L	2	MS-3	450	6th	Bottom seal
		4L	2	MS-3	D.W. 300	3d	Do.
		7L	3	MS-3	450	4th	Top seal
7	36	3L	2	MS-3	450	4th	Bottom seal
		6L	3	MS-3	D.W. 300	4th	Do.

1/ For explanation of code, indicating type of package, see table 2.

Table 4.--Analysis of results of drop tests with rice packages stored at Marcus Hook, Pa., November 13, 1953 to June 11, 1954

Weight of package:	Kind:	Weight:	Bottom seal:	Top seal:	Side seam:	Film breakage:	Total failures:
Pounds			Number	Number	Number	Number	Number
1	MS-3	450	1	0	0	2	3
	MS-3	D.W. 300	1	0	0	0	1
2	MS-3	450	2	0	1	1	4
	MS-3	D.W. 300	1	0	0	0	1
	P-1	D.W. 300	0	0	0	0	0
3	MS-3	D.W. 300	1	1	0	0	2
	MS-3	D.W. 400	0	2	1	0	3
	MS-3	450-inner)	0	0	0	0	0
	MS-3	300-outer)					
	Total		6	3	2	3	14

The bags were reweighed at the time of each test and the results were compared with the original weight (table 5). The weights of the packages when sealed in bales did not fluctuate much; the greatest changes were noted in the double 300 P-1 (nonmoistureproof) film.

Tests at Michigan State University

The results of the drop tests at Michigan State University are given in tables 6 and 7. Data on only those packages that were damaged in dropping are given. Only two sets of packages from one bale were drop-tested March 1, 1954; the third set having been removed and exposed to air for 3 months, after which it was drop-tested. The duplex 300 MS-3 1-pound packages were the most durable of those tested. However, the same film on the 3-pound bags resulted in the greatest number of failures. Of the bags exposed to air for 3 months, the single MS-3 450 bag lost 2.4 percent weight, compared with 1.8 percent for the duplex P-1 bag. When drop-tested, the 3-L (single 450 MS-3) bag split full length (not at seam) on the sixth drop. Also, the 7-L (double 450 MS-3) 3-pound bag split full length at the front seam on the sixth drop.

Table 5.--Change in weight of the rice packages in each bale (weight at end of the test period compared with original weight)
Marcus Hook, Pa., November 13, 1953 to June 11, 1954

Package code	Gain or loss in weight						
	Bale number						
	1	2	3	4	5	6	7
	Grams	Grams	Grams	Grams	Grams	Grams	Grams
1 H	0.2	-	0	0	-0.5	-	-0.6
1 L	.6	0.5	0.7	0.7	0.5	0.1	0.1
2 L	.2	.2	.4	.6	.3	.4	.3
3 L	.1	.5	.6	.4	0	-0.1	-0.1
4 L	.1	.1	.2	.2	0	0	.1
5 L	.9	.8	0	.6	-0.1	.2	.4
6 L	.1	.1	.2	.2	0	.2	.1
7 L	.1	.1	.1	.1	0	.2	.1
8 L	0	.1	.2	.1	0.1	.1	.1

Table 6.--Results of drop tests measuring durability of the rice packages stored at Michigan State University

Bale number	Weeks stored	Package code	Package weight	Film Kind	Drop test fail-ures	Location of break or description if at other than seam
	Number		Pounds		Number	
1	6	2 L	1	MS-3	D.W.300	- 1" tear
		6 L	3	MS-3	D.W.300	5 Badly broken
		7 L	3	MS-5	D.W.450	- Seam
		7 L	3	MS-5	D.W.450	- Do.
2	12	1 LB	1	MS-3	450	5 2" tear
		2 LB	1	MS-3	D.W.300	5 3" outside tear
		3 LC	2	MS-3	450	End seal imperfect
		3 LB	2	MS-3	450	Full length tear
		3 LC	2	MS-3	450	5 6" tear
		4 LB	2	MS-3	D.W.300	5 Outside wall split
		5 LA	2	P-1	D.W.300	5 Full length tear
		5 LC	2	P-1	D.W.300	5 4" tear outside wall
		6 LA	3	MS-3	D.W.300	5 Outside wall torn
		6 LB	3	MS-3	D.W.300	1-5 Both walls broken
		6 LC	3	MS-3	D.W.300	5 Outside wall broken
		7 LA	3	MS-3	D.W.450	6 Do.
		7 LB	3	MS-3	D.W.450	6 Do.
		8 LA	3	MS-3	D.W.450x300	1-5 4" and both walls
		8 LB	3	MS-3	D.W.450x300	5 Outside wall
		8 LC	3	MS-3	D.W.450x300	6 Do.
3	18	1 LC	1	MS-3	450	3 1/2" tear
		4 LC	2	MS-3	D.W.300	4-6 4" tear
		2 LB	1	MS-3	D.W.300	6 Side wall split
		5 LB	2	P-1	D.W.300	6 4" shatter
		7 LB	3	MS-3	D.W.450	5 Outside shattered
4	24	1 HA	1	MS-3	450	2 Closure at top seam
		3 LA	2	MS-3	450	5 Outside shattered
		3 LB	2	MS-3	450	5 Do.
		4 LC	2	MS-3	D.W.300	6 Do.
		4 LB	2	MS-3	D.W.300	2 Top seal
		6 LA	3	MS-3	D.W.300	3-5-6 Do. 1/
		6 LB	3	MS-3	D.W.300	5 Outside shattered
		6 L	3	MS-3	D.W.300	5-6 Do. 2/ 2/
		7 L	3	MS-3	D.W.450	4-6 Top and bottom/seals
5	30	3 LB	2	MS-3	450	3 Bottom seal
		3 LC	2	MS-3	450	4 Do.
		6 LA	3	MS-3	D.W.300	6 Seam split
		6 LC	3	MS-3	D.W.300	1-4 Bottom & top seals
		8 L	3	MS-3	D.W.300x450	4 Bottom seal
6	36	1 L	1	MS-3	450	3 Top seal
		7 L	3	MS-3	D.W.450	6 Side seam
		8 L	3	MS-3	D.W.450x300	2 Bottom seal
7	42	1 HB	1	MS-3	450	1 Bottom seal
		1 L	1	MS-3	450	2-5 Outside 3" tear
		5 L	2	P-1	D.W.300	0 Insert hole

1/ Outside film split 3/4" on 5th drop and split open on 6th drop.

2/ Outside film split 6" on 6th drop.

Table 7.--Analysis of results of drop tests of rice packages stored at Michigan State University, November 23, 1953 to August 23, 1954

Size of package Pounds	Film		Closure failures			Film fail- ures	Total
	Kind	Weight	Bottom	Top	Seam	ures	
			Number	Number	Number	Number	Number
1	MS-3	450	1	2		3	6
	MS-3	D.W.300				3	3
2	MS-3	450	2	1		4	7
	MS-3	D.W.300		1		3	4
	P-1	D.W.300				3	3
3	MS-3	D.W.300	1	2	1	6	10
	MS-3	D.W.450	2	1	3	5	11
	MS-3	D.W.300x450	2			3	5
		Total	8	7	4	30	49

Film Breakage Patterns

In the drop tests, some of the bags showed unusual breaks. Figure 4 shows how the outside film of a 2-pound duplex bag of 300 MS-1 broke when dropped, while the inner bag tended to wrinkle. The film of a 2-pound bag of single weight 450 MS-3 shattered from one point (fig. 5) which is typical especially of the outside film of duplex bags. For the first 3 months little breakage occurred, but as the packages aged, some of the films tended to weaken.



Figure 4.--When this package encased in duplex 300 MS-3 was dropped, the outside film was broken. Pencil lines on paper, inserted under outside broken film, indicates breakage pattern.



Figure 5.--The pencil-like lines show the pattern of the break when a single wall 450 MS-3 bag shattered. This was typical of how film breaks from one point.

Comparison of Results of Drop Tests

The results of all the drop tests are shown in table 8. In overall results, the least breakage occurred with the duplex 300 MS-3 film in 1-pound packages, and the greatest with the same film in 3-pound packages.

The nonmoistureproof film was very satisfactory in durability tests. However, this film did permit the greatest fluctuation in weight.

WEIGHT CHANGES

The changes in weight of packages of rice are shown in tables 9, 10, and 11, for Crowley, Washington, D. C., and East Lansing, respectively. The greatest changes were in the packages stored in heated offices in Washington, D. C. Both the cellophane and the rice in these packages were dried to a greater extent than those stored in Louisiana and Michigan.

Table 8.--Analysis and summary of results of drop tests of rice packages at Louisiana, Michigan, and Pennsylvania, October 1953 to September 1954

Size of package	Kind	Weight	Failure of						Total
			Seal 1/			Film 1/			
			L	M	P	L	M	P	
Pounds									
1	MS-3	450	0	3	1	0	3	2	9
	MS-3	D.W. 300	0	0	1	0	3	0	4
2	MS-3	450	0	3	3	1	4	1	12
	MS-3	D.W. 300	0	1	1	0	3	0	5
	P-1	D.W. 300	0	0	0	0	3	0	3
3	MS-3	D.W. 300	3	4	2	0	6	0	15
	MS-3	D.W. 450	2	6	3	0	5	0	16
	MS-3	D.W. 300x450	1	2	0	0	3	0	6
Total			6	19	11	1	28	3	70

1/ L=Crowley, La., M - East Lansing, Mich., P=Marcus Hook, Pa.

Table 9.--Change in weight of 1- to 3-pound packages of milled rice stored at Crowley, La.

Year and month	Original weight								
	Identification								
	1 H	1 L	2 L	3 L	4 L	5 L	6 L	7 L	8 L
1953	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams
October	464	465	463	902	925	911	1,338	1,378	1,380
gain or loss									
November	-4	-1	-1	11	0	6	-1	-2	-1
December	2	3	1	8	0	14	1	2	2
1954									
January	1	3	2	3	2	-1	0	1	1
February	1	3	1	4	0	2	2	1	2
March	-3	-4	-1	-6	0	-8	0	0	0
April	1	3	2	5	2	6	2	3	3
May	-3	-4	-1	-7	-1	-10	-1	-1	-1
June	-3	-3	-1	-5	-1	-5	-1	-2	-3
July	0	1	-1	0	-2	2	-3	-2	-2
August	0	0	0	1	0	0	1	-1	-
Greatest monthly change	-4	-4	2	-11	2	14	-3	3	3
Percent	0.9	0.9	0.4	1.2	0.2	1.5	0.2	0.2	0.2

Table 10.--Changes in weight of 1- to 3-pound packages of milled rice stored at Washington, D. C.

Month and year	Identification								
	1-H	1-L	2-L	3-L	4-L	5-L	6-L	7-L	8-L
1953	Original weight in grams								
November	458	458	462	908	919	917	1,349	1,382	1,376
	Gain or loss in grams (from preceding month)								
December	-12	-11	-5	-21	-3	-27	-8	-10	-5
1954									
January	-5	-2	+1	-9	-2	-7	-1	-4	-10
February	-1	-2	-2	-1	0	-1	-1	-1	0
March	-4	-2	-5	-10	-4	-2	-6	-2	-3
April	-1	0	+3	+2	-3	+1	-1	-4	-2
May	+1	+1	0	+1	-3	+7	-4	-2	-4
June	0	+1	-2	+4	-2	0	-1	-3	-1
July	-	-	-	-	-	-	-	-	-
August	+9	+14	+7	+13	+6	+20	+4	+7	+5
Greatest monthly change	-12	-11	-5	-21	-4	-27	-8	-10	-10
Percent	2.6	2.4	1.1	2.3	0.4	2.9	0.6	0.7	0.7

Table 11.--Changes in weight of 1- to 3-pound packages of milled rice stored at East Lansing, Mich.

Month and year	Identification								
	1-H	1-L	2-L	3-L	4-L	5-L	6-L	7-L	8-L
1953	Original weight in grams								
November	456	460	460	913	915	911	1,341	1,377	1,372
	Gain or loss in grams (from preceding month)								
December	-5	-3	-1	-7	-2	-8	-2	-8	-3
1954									
January	-3	-2	-1	-5	-1	-4	-2	+4	-2
February	-2	-1	-1	-2	-1	-1	-1	-1	-1
March	-2	-2	-1	-4	-2	-4	-2	-2	-2
April	-1	0	-1	-2	-3	+1	-3	-2	-2
May	-2	-2	-1	-4	-2	-4	-2	-3	-4
June	+3	+5	0	+8	-1	+14	-2	-1	-2
July	-1	-2	-1	-2	-1	-4	-1	-2	-1
August	+2	0	0	+3	0	+4	-1	-2	-1
Greatest monthly change	-5	+5	-1	+8	-3	-8	-3	-8	-4
Percent	1.1	1.1	0.2	0.9	0.3	0.9	0.2	0.6	0.3

MOISTURE LOSS STUDY



Figure 6.--The various sizes of bags and kinds and combinations of films that were filled with rice and exposed to the air. The hygrothermograph recorded changes in temperature and humidity. The packages were exposed only to subdued indirect natural light.

Michigan State University was the only place where a hygrothermograph was operated (fig. 6) to determine the range of humidity and temperature that might be expected in retail outlets. In table 13, maximum and minimum temperatures and relative humidities are indicated by weeks for the test period. From December to June the humidity was low. In only 8 weeks in this 6-month period did the humidity go above 40 percent, and it fell below 32 in all but one week. From June 1 to September 13, the relative humidity range was much higher. The weekly maximum humidity from 52 to 79 percent and the minimum also averaged considerably higher than in the previous period.

This indicates why it is so necessary to use cellophane that can withstand a wide range of conditions.

In order to obtain the greatest efficiency in the use of cellophane, the relative humidity in a room should be maintained at a rather high level, especially in cold winter months when heated rooms naturally tend to be low in humidity. Also, the cartons or bales should be stacked under conditions of controlled humidity so that when filled, they will have no tendency to absorb moisture from the cellophane.

If cellophane packed in shipping cartons is stored in a heated building where the relative humidity is low, it will give off moisture to the dry air. Film that has been kept in unheated buildings should be tempered before being shipped. On the other hand, cellophane should not be stored where the relative humidity is too high, as this may result in beading and banding of the roll stock, loss in seal strength, and injury to moistureproofness and printing.

Table 12.--Weekly maximum and minimum temperature and humidity range to which rice was exposed in weight change studies at Michigan State University

Year and day on which week began	Temperature		Relative humidity	
	High	Low	High	Low
1953	F	F	Percentage	
Dec. 7	78	60	38	20
14	64	52	37	26
21	65	54	40	24
28	65	52	32	22
1954				
Jan. 4	62	52	30	23
11	61	50	28	20
18	64	48	44	20
25	64	53	40	22
Feb. 1	63	58	32	22
8	68	48	39	20
15	72	57	47	20
22	67	58	33	23
Mar. 1	66	52	33	22
15	69	54	40	23
22	72	61	50	24
29	70	59	32	22
Apr. 5	79	61	50	24
12	86	64	54	22
19	84	67	46	24
26	88	65	50	32
May 3	85	61	40	20
10	105	64	40	20
17	105	68	32	16
24	100	72	48	18
June 1	104	66	54	24
7	111	80	54	28
14	103	78	62	36
21	104	76	70	22
28	107	72	56	23
July 6	97	70	58	28
12	105	76	61	22
19	104	73	59	28
26	104	77	62	26
Aug. 2	99	70	61	32
9	90	64	65	35
16	94	67	79	35
23	98	66	74	40
30	91	68	54	36
Sept. 7	88	67	52	30
13	82	65	64	38

INSECT PENETRATION OF CELLOPHANE PACKAGES 1/

Both moistureproof and normoistureproof cellophane packages were tested in the laboratory for resistance to stored-grain insects. Duplicate sets of all of the different weights and kinds of bags were entered by insects in less than 3 months. In most instances the insects entered through the folded flaps either at the top or bottom. Heat-sealed seams afforded some protection against penetration. After 6 months' exposure, nearly every package contained one or more holes made by either exit or entrance of insects to the bags. The heavy bags and the duplex bags did not give much more protection than did the light-weight bags.

CARE OF CELLOPHANE IN STORAGE

Cellophane is made from cellulose derived from wood pulp combined with a few other materials, and can be obtained in many different weights and types, either moistureproof or normoistureproof. Since there are so many kinds and weights available, it is essential that packagers, handlers, and homemakers choose wisely if they are to realize optimum economy and performance.

Moisture and temperature of storage conditions have much to do with the life and usefulness of cellophane. When cellophane packages are kept in heated rooms or in rooms of low humidity for long periods, the film has a tendency to become brittle and lose durability.

Packagers, wholesalers, and retailers should use old stocks before acquiring new supplies. When film on hand is not all used during one season of the year, but must be carried over into a season which is different in temperature and humidity, it may be damaged unless it is carefully stored in a room with controlled temperature and humidity (table 13).

1/ This research was conducted by the Stored-Product Insects Section.

Table 13.--Recommended storage conditions for cellophane

Form and storage condition of stock	Kind of film	
	Moistureproof	Nonmoistureproof
<u>Sheet</u>		
Temperature range	65° - 75°	65° - 75° F.
Relative humidity	34 - 65 percent	35 - 50 percent
Stacking	Not over 12" high	Not over 6" high
<u>Roll</u>		
Temperature	62° - 75° F.	62° - 75° F.
Relative humidity	40 - 50 percent	40 - 45 percent
Stacking rolls	On end	On end
Cartons	Not over 5 high	Not over 5 high
<u>Bags</u>		
Temperature	65° - 75° F.	65° - 75° F.
Relative humidity	50 - 65 percent	40 - 45 percent
Stacking shipping cartons	Not over 8 high	Not over 8 high

Do not carry more than a 3-months' supply of film at any one time.

Since cellophane and other packaging materials are costly, every precaution should be exercised to avoid waste of materials and make each unit of film do its part. When rolls of film are removed from containers in the plant, the edges may be nicked if precautions are not taken. These nicks cause the film to break on the packaging machine, and materials as well as time and labor are wasted. Always retain the wrapper until the roll is used up. Remove the unused roll from the machine at the end of the day, place the roll in the original wrapper, and store it properly.

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